NASA SBIR/STTR Technologies

A2.02-9783 - Eulerian Transported PDF Framework for Scramjet Flowpath Analysis

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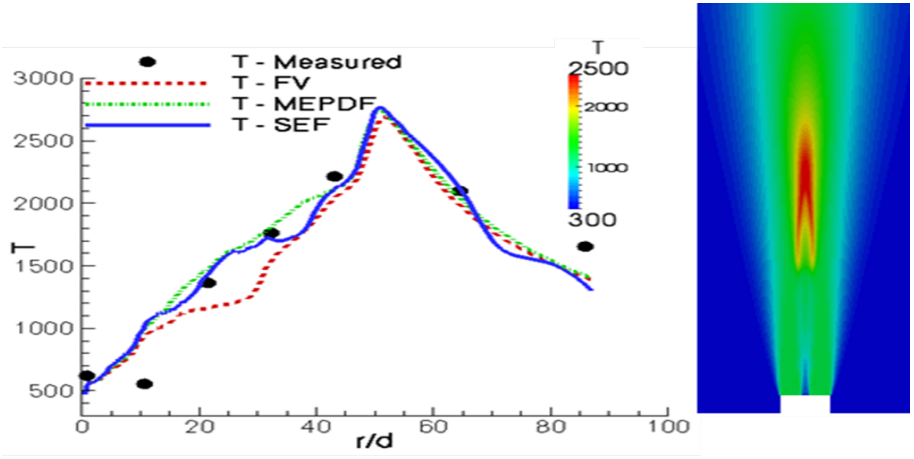
Identification and Significance of Innovation

Significant challenges in rapid development of scramjets include complex flow physics; design methods; difficulty of producing realistic experimental conditions. The role of computational fluid dynamics is crucial in design and development of the scramjet engines. The proposed innovation includes development of a comprehensive Eulerian transported PDF (TPDF) methods framework coupled with efficient RANS/LES flow solvers for simulating high-speed reacting flows. In Phase I of this project we developed two Eulerian TPDF methods and demonstrated their ability to capture moderate to strong turbulence chemistry interactions in sub- and super-sonic jet flames. Key Innovations: 1.) Development of a Eulerian TPDF framework for simulating turbulent reacting flows; 2.) Validation of the solvers in configurations which are relevant to scramjet flow path analysis and development; and 3)Development of chemistry-acceleration framework to improve computational speeds up to an order of magnitude.



Computed and Measured [Cheng et al., Combust. Flame, 99:157-173, 1994] Mean Axial Temperatures for a supersonic jet flame using Finite volume and Eulerian Transported PDF Methods

Estimated TRL at beginning and end of contract: (Begin: 3 End: 6)

Technical Objectives and Work Plan

The overall goal of this Phase II SBIR project is to develop, validate and deliver an accurate Eulerian TPDF methodology for modeling turbulent combustion in complex flow fields such as scramjet engines. In Phase I the feasibility of the proposed Eulerian TPDF approach for accurately and efficiently modeling turbulence-chemistry interactions has been demonstrated. Specific objectives of Phase II include the following: 1) Development of Eulerian TPDF methods in a coupled solver for application to large-scale CFD simulations of scramjet engines 2) Implementation of improvements to Eulerian Transported PDF methods for multi-species, finite-rate CFD analysis of reacting flows using both RANS and LES techniques; 3) Development of innovative chemistry-acceleration tools to enable analysis of larger engines and more complex chemistry in a scramjet configuration, to allow better designs; and 4) Verification and Validation framework for Eulerian TPDF methods developed in the Phase II effort.

NASA Applications

The tools developed in this SBIR project will be directly useful to NASA's Hypersonics Program. The methods will be applicable to high-speed combustion devices such as ramjets and scramjets as well as propulsion devices such as solid rocket motors, liquid rocket engines and gas turbine combustors. The Eulerian transported PDF methods are an area of active research and have excellent promise to provide accurate and computationally tractable models for complex turbulence-chemistry interactions.

Non-NASA Applications

The technology will facilitate significant advancement in use of CFD analysis in applications including propulsion devices, gas-turbine combustors and other combustion devices. The software will be beneficial to OEMs such as GE, Pratt & Whitney, Williams International, and Rolls Royce in designing combustion devices. The developed tools will be of great interest to commercial CFD OEMs for integrat

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